CALIFORNIA
ENERGY
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California Hydroelectric Energy Outlook

FINAL STAFF REPORT

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The timely hydrologic forecasts and data compilations provided by the California Department of Water Resources provide the most essential tracking tools for hydroelectric energy forecasting, this year and every year. The insights of agency and utility hydrologists and portfolio managers is gratefully appreciated. This statewide energy forecast is tempered and informed by the forecasts of individual agencies and utilities, some very public, and others proprietary and confidential. Errors in theory, method, interpretation and presentation remain the ownership of the author.

CALIFORNIA HYDROELECTRIC ENERGY OUTLOOK

Hydro Energy Summary

The outlook this year for California's hydro generation is fair to good. The ability to draw down reservoirs this summer after an average year (2003) is likely to provide enough fuel to sustain **hydro energy production at 85 percent of average**. At the end of April, water storage in reservoirs was 102 percent of average historical conditions. Though a warm and dry spring led to an early melt of the Sierra snowpack, reservoir management is expected to optimize the value of this stored energy.

Flexibility in water releases allows load-serving utilities to meet daily, monthly, and annual peak demand for electricity. Besides serving peak loads and being used to meet environmental requirements, stored water will also be optimized for its economic value.

Hydro Capacity Summary

The effect of one dry year on the summer peak for dependable hydro capacity is much less dramatic than it is on energy generation. Capacity to generate power is most variable at large storage reservoirs. At these sites, the vertical drop of water to the powerhouse (gross head) changes with lake levels, which fluctuate according to shifting seasonal priorities for flood control, water storage, and water delivery.

Many hydro resources are highly predictable and dependable, such as large pumped storage projects, adding stability to the generation landscape. Unlike other regions, California has many hydro plants fueled by relatively small water volumes with high gross heads, using diversions, forebays and penstocks. A powerhouse with a fixed power drop has a constant dependable capacity, even when below-average water supplies reduce total energy output. Additionally, some man-made lakes are kept artificially full year-round, to regulate downstream releases. After-bay type plants such as Iron Gate (on the Klamath), Keswick (below Shasta), and Nimbus (below Folsom) essentially have a single generating capacity for all seasons. Other hydro resources are normally finished working by September every year, such as tributary QF facilities, run-of-canal plants in irrigation districts, and Pine Flat on the Kings River, a low elevation storage reservoir.

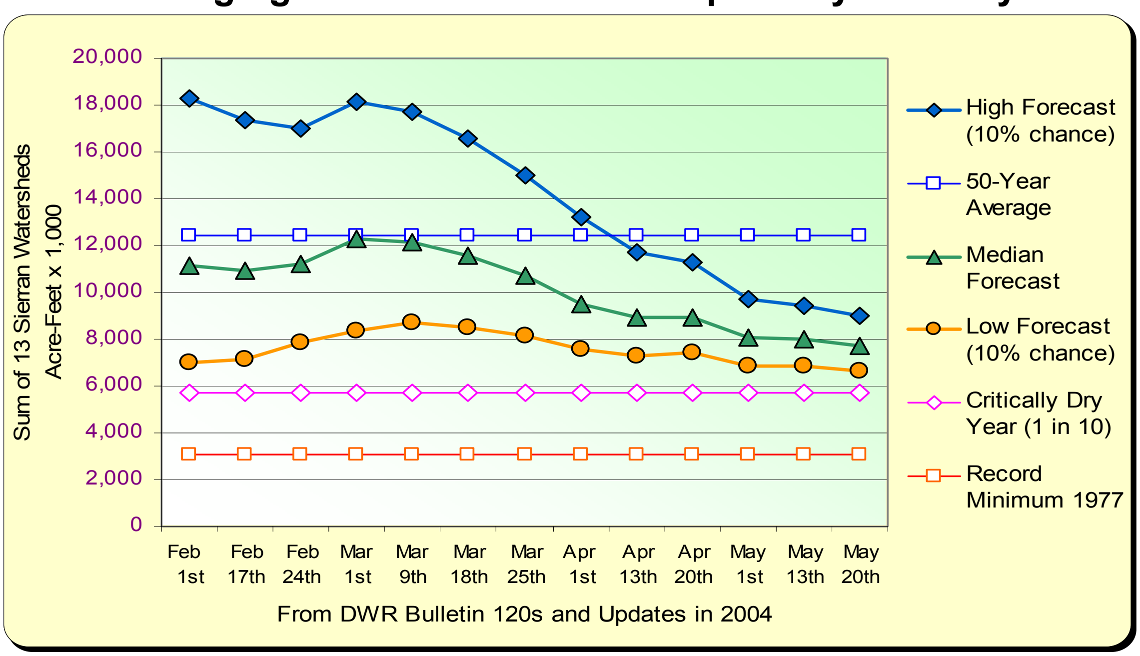
The estimated summer peak dependable capacity for hydrogenation during a dry year declines by approximately 500 MW compared to average water conditions. Unlike the energy forecast, which is 85 percent of average for this year, total in-state hydro capacity will probably be at 95 percent of average through late summer. Capacity to serve peak summer loads, especially from hydro resources with flexible dispatch, will be close to, but slightly below historical averages. By the fall months, statewide hydro capacity will be more diminished when compared to seasonal norms. Managers of utility portfolios and water agencies then will hope, reasonably and prudentially, that next winter's rains will refill the reservoirs. In California, it takes two consecutive dry years to significantly reduce hydro capacity for the summer months of July, August, and September.

California Water Supplies

The California Department of Water Resources produces detailed forecasts of water supplies. These forecasts focus on expected "runoff" during the months of April to July. This runoff estimate is calculated for "unimpaired" conditions, as if there were no dams and diversions. The forecasts commence each year on February 1 with a high degree of statistical uncertainty between most likely, wet, and dry year scenarios.

Figure 1 shows how this year's forecasts have changed over the last 15 weeks. The last major winter storm arrived February 24-26, and boosted the median forecast almost to the 50-year average. (That storm was particularly helpful to the southern Sierra which added more than five feet of snow in some locations, in an otherwise very dry year.) That late-February storm was the last significant weather system to hit California this year. Since then, hydrologic forecasts have shown a steady decline

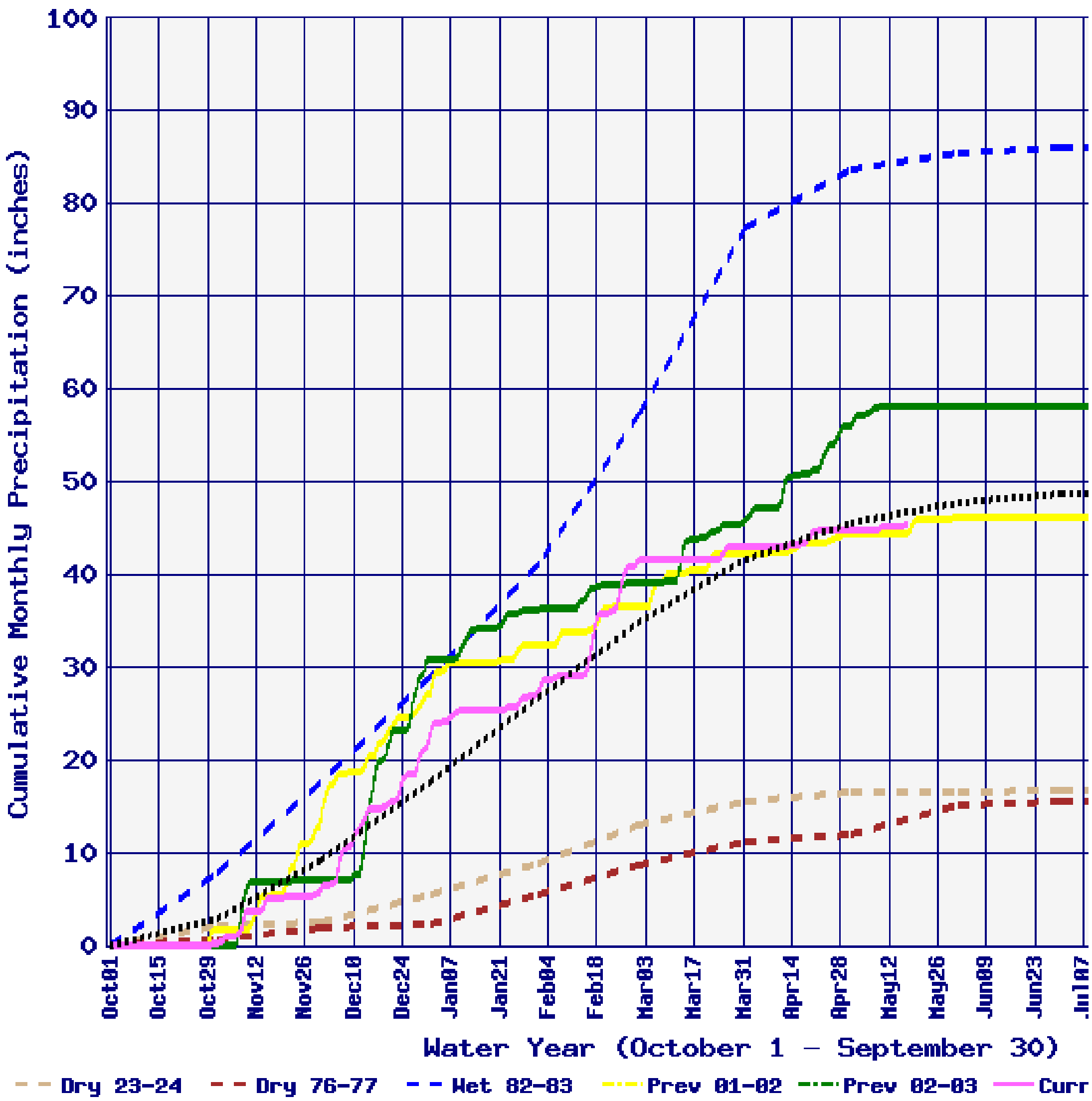
Figure 1
Changing Runoff Forecasts for April-July thru May 20



in expected spring runoff for 13 major hydropower rivers, from the Pit to the Kern. Interestingly, the “low forecast”, which always has a 90 percent chance of being exceeded, ended the season very close to where it began on February 1.

What **Figure 1** does *not* reveal is that precipitation and runoff *before* April 1 were very close to average, much of which was impounded for use later. **Figure 2** provides some of this insight, showing cumulative precipitation for eight stations in the northern Sierra, from Blue Canyon (east of Sacramento) north to Shasta Dam. The current water year (shown with a pink line), began with a bone-dry October.

Figure 2
Northern Sierra Precipitation, Average of 8 Stations



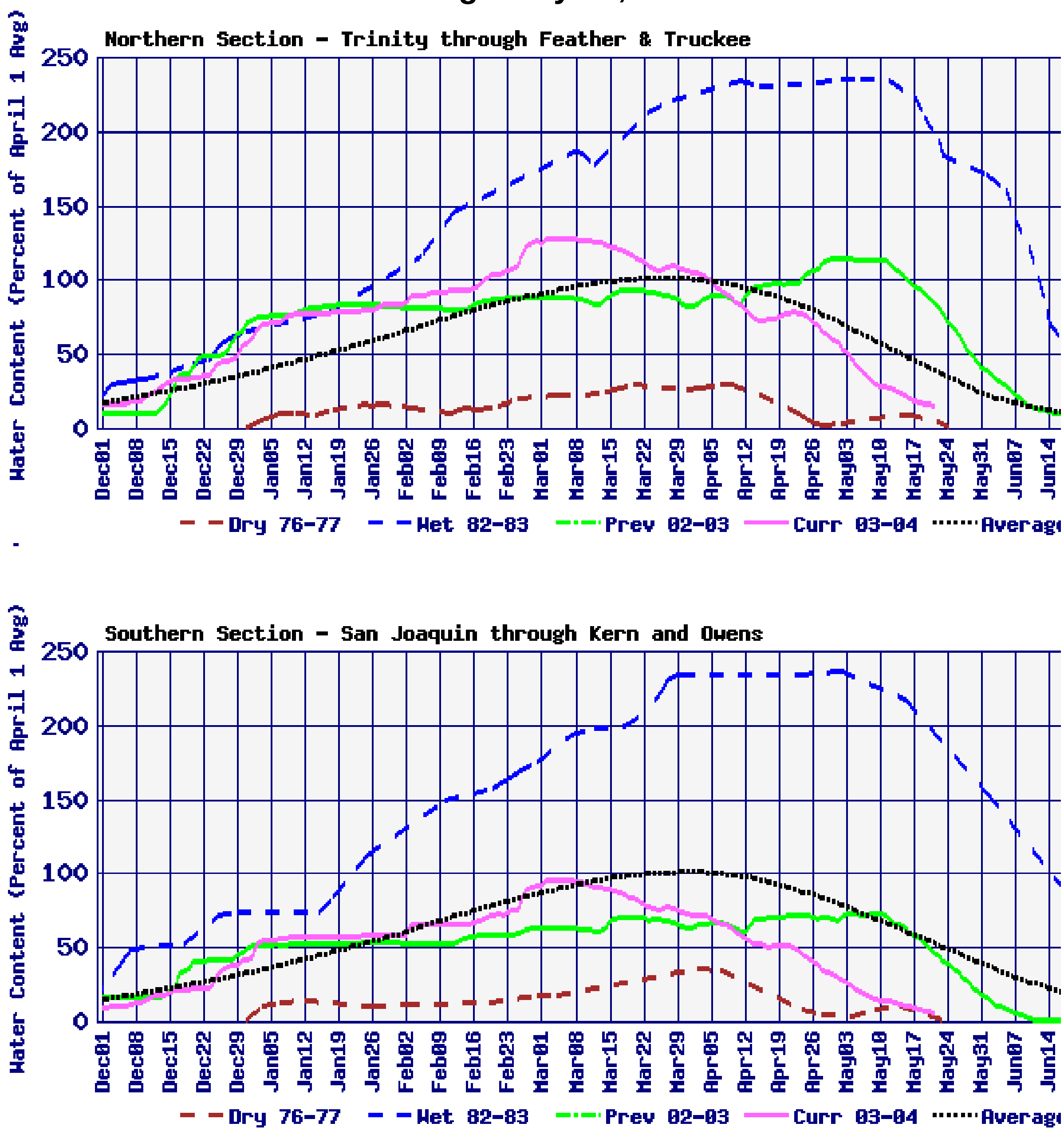
03-04

---- Average (annual total = 50 inches)
From California Department of Water Resources, May 18, 2004
http://cdec.water.ca.gov/cgi-progs/current/PLOT_ESI

A dry start this water year was similar to water year 2003 in dark green. By mid-December, cumulative rain and snowfall amounts were up to average for that date (the dashed black line), and remained above average through April 12. In 2004, however, there were no late-spring storms to boost cumulative water delivery totals.

Figure 3 illustrates how a good mid-winter snowpack was steadily eroded. Two timelines are shown, one at top for the northern Sierra, and a second below for the

Figure 3
Northern and Southern Sierra Snowpacks
Through May 20, 2004



southern Sierra. Readers can find the middle Sierra at http://cdec.water.ca.gov/cgi-progs/current/PLOT_SWC. On *average* the northern Sierra snowpack reaches its maximum weight (all from water) on April 1, while the southern Sierra tops out on March 27. This year, the peaks came shortly after March 1. By May 6, the statewide snowpack was just 48 percent of average for this date, and melting steadily. By April 1, much of the southern Sierra snowpack had already become a liquid asset. For the Tule River watershed, with relatively low elevations, the May 1st estimate for April-July runoff was just 26 percent of average. Elsewhere in the Tulare Lake region, April-July runoff estimates ranged from 62 percent on the Kings River, to 47 percent on the Kern River.

Figure 4 shows cumulative distribution of precipitation in the state's ten hydrologic regions since October 1, and how that generally influences statewide hydroelectric supplies. As shown in **Figure 4**, the Sacramento River region received 90 percent of its normally abundant water supply, even if delivery timing was anything but average. Precipitation in the San Joaquin region was just 80 percent of average, but this region has the best ratio of reservoir storage (11.4 million acre feet) to average runoff (7.9 MAF), a ratio equal to 144 percent. This ratio in the Sacramento River is 71 percent, and in Tulare Lake it is 61 percent. Generating capacity and reservoir size in the Central Valley make the Sacramento River, San Joaquin River and Tulare Lake the most important hydropower regions in the state. The cumulative precipitation and expected *annual* runoff in these regions are significant factors in this statewide forecast. This year, cumulative precipitation is the better predictor of energy output than unimpaired spring-summer runoff. March was a record-breaking warm and dry month throughout the West. April was also warm and dry in California (though April in the Southwest was much wetter than average). For energy forecasts, what matters is the matchup of water delivery to infrastructure. Turbine capacity is the foremost factor. Adequate or abundant storage and flexibility in dispatch are essential for optimization.

Only two California rivers are forecast to have above-average runoff this year, the Upper Sacramento and Trinity. Both are expected to yield 106 percent of average. Looking forward 12 months through March 2005, the federal Central Valley Project estimates that energy generation at their dam sites will be 97 percent of average. The workhorse Feather River is expected to produce 86 percent of average annual runoff. In the San Joaquin River region, expected annual runoff ranges from 76 percent on the Tuolumne down to 70 percent on the Merced.

Looking elsewhere in California, there is relatively little installed capacity in the Bay Area, Central Coast, or South Coast. Very dry conditions in South Coast (60 percent of average precip) will affect local and groundwater supplies, and the need for water imports, but this is not of major importance to the statewide hydropower picture. Water storage in Southern California is primarily filled by imports, not local runoff. In the southeast and northwest corners of the state, the Colorado River and North Coast hydrologic regions have major storage reservoirs upstream in other states.

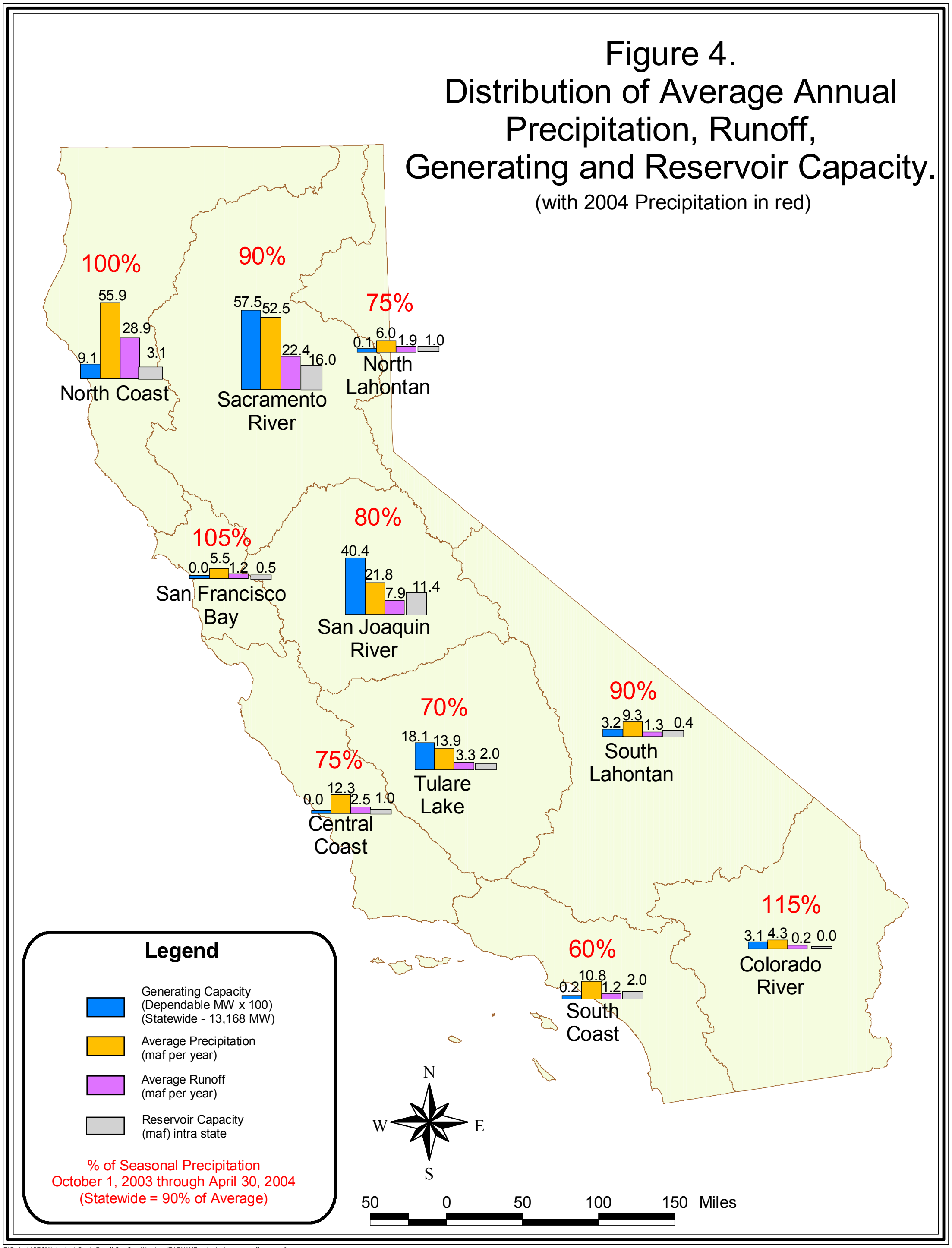


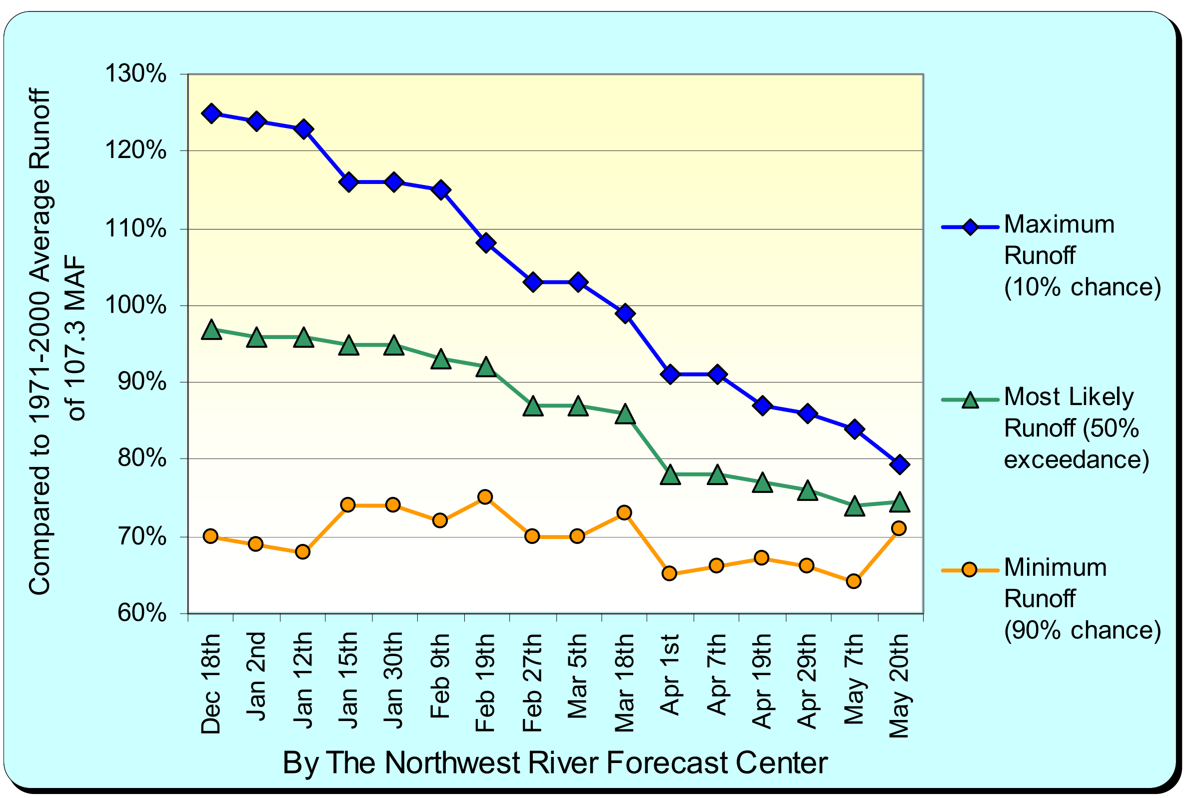
Figure 4.
Distribution of Average Annual Precipitation, Runoff, Generating and Reservoir Capacity.
(with 2004 Precipitation in red)

Despite record warm and dry conditions in much of interior California during March and April 2004, actual runoff in these months was very close to average. Most of this was due to early snowmelt. The near absence of March and April rainfall meant that nearly all this snowmelt could be slowed or captured in reservoirs. This year, unlike last, only a few drops (acre-feet, actually) were spilled. Fortunately, state, federal, and utility dam managers have been able to retain more water than average during April so that storage was just above normal levels, at least for the short term. As of April 27, water storage in 12 major reservoirs in Central California was 103 percent of average for that date. The normal winter-spring water delivery season is nearly done. The water year for the Sacramento Valley is officially rated “below normal”, while the San Joaquin Valley is rated “dry.” A fourth consecutive below-average water year is now a certainty.

Pacific Northwest

Water conditions elsewhere in the West are also below average or dry, but are not considered critically dry. In the Northwest, total Columbia River runoff measured at The Dalles is likely to be just 75 percent of average for all forecast time periods between January and September (**Figure 5**). In the May 20th forecast, there is a 10 percent chance (the “minimum runoff”) that Columbia River flows will be less than 71 percent of average, and a 10 percent chance (the “maximum runoff”) that volumes will be greater than 79 percent of average.

Figure 5
Changing Runoff Forecasts for January-July
Columbia River at The Dalles, Oregon



This will be the fifth consecutive year with below-average water in the Columbia Basin, but it is nowhere close to record dry conditions (50 percent). Interestingly, the most recent low forecast (71 percent) is nearly equal to the first forecast of the water year (70 percent) on December 18. Over the last 5 months, the “maximum” and “most likely” runoff forecasts in the Pacific Northwest have declined significantly. These declines are very similar to high and median runoff forecast declines in California over the last 2_ months as shown in **Figure 1**.

Hydropower accounts for about 66 percent of generating capacity in the Pacific Northwest, and produces about 54 percent of the energy generated in that region. The Northwest River Forecast Center produces long-range hydrologic forecasts for the Columbia River Basin. It is part of the National Weather Service in Portland, Oregon. Forecasts include snow survey data as inputs from January 1 to June 1, along with short-term temperature and precipitation forecasts for up to 10 days ahead. They are available at: http://www.nwrfc.noaa.gov/water_supply/ws_fcst.cgi

California and the Pacific Northwest are natural partners in electricity trading. The two regions have complimentary supply and demand patterns. The spring and early summer is a period of low demand and high supply in the Pacific Northwest, which generally makes a large amount of surplus power available for export to California. That surplus is currently about 1,000 megawatts of firm energy. The firm energy forecasts of the Pacific Northwest system reflect no more than that expected under critical dry water conditions. Amounts of excess energy above critical water levels are available for sale into California spot markets throughout the summer. Also, firm energy that is surplus after serving regional loads is available for spot-market sales. The average flow of power to California for the last 30 days, April 21 to May 20, has been 2,516 megawatts. In the winter months, the availability of electricity supplies from California helps to meet demand in the Pacific Northwest, especially during very cold weather. Thanks in part to long-distance transmission, electricity exchanges, bilateral contracts, and open markets the likelihood of a power shortage in the Pacific Northwest during the winter of 2004-2005 is less than 1 percent according to the Northwest Power and Conservation Council.

Again, in the Pacific Northwest, *power* and *capacity* will be near normal to help meet the peak hours of summer demand in California, but the total volume of *energy* produced during the year will be reduced. On the Columbia River, some water releases are scheduled all year to benefit fish, navigation, and other purposes, including energy exchanges with California utilities, and power sales into California markets. There are some large and extra large reservoirs in the Pacific Northwest, but the total volume of precipitation and runoff (107.3 million acre feet at The Dalles, on average) are even larger. The ratio of reservoir storage to average annual runoff is only 30 percent in the Pacific Northwest, compared to about 400 percent on the Colorado River, and 225 percent on the Stanislaus River in the central Sierra. In the Pacific Northwest, proportionately much less water can be held back for the next year. The Pacific Northwest depends on hydro for total generation to a much greater extent than California. Consequently, this region appears to be more vulnerable to the effects of a one-year drought than California.

Colorado River

California is approved to take about 4.35 million acre feet from the Colorado River in 2004. Five years of below-average precipitation in this basin as well as negotiations on the distribution of water have ended years of California receiving surplus Colorado River water.

The outlook is for continued drought in the Upper Colorado Basin. Like California, an early snowmelt produced March and April runoff that was close to average. Inflows to Lake Powell were 81 and 83 percent of average. On May 1, Lake Powell was down to 42 percent of its usable capacity. Forecast inflow to Lake Powell will be just 48 percent of average this April-July, equal to 3.8 MAF. Inflow to Lake Powell was only 53 percent of average in 2003. In 2000, 2001, and 2002, this inflow was 62 percent, 59 percent, and 25 percent of average, respectively, with 2002 being the record low. If the drought in this area continues, the turbines at Lake Powell could be high and dry by late 2006. Flaming Gorge reservoir was at 70 percent usable capacity on May 1, but most other reservoirs in the Upper Basin were rated much below average. In the eastern Great Basin, the April-July forecast runoff will be much below its 1971-2000 average, and will vary from 20 percent to 70 percent of average. Huge reservoirs such as Powell and Mead were intended to help the Colorado Basin cope with prolonged multi-year droughts, a condition that is a “normal aberration” for most climates, especially in the West. Five years of drought is the normal maximum duration for droughts during the historic gauged record, though tree ring data indicates there were longer and worse droughts prehistorically. Significant drought relief is not expected before next year.

The outlook is mixed in the Lower Basin. Lake Mead is about 60 percent full, and receding very slowly. Lake elevation was 1,139.12 feet on January 1, 2004. It is forecast to be 1,126.16’ on January 1, 2005, and 1,119.63’ on January 1, 2006. In that same two-year span, storage in Mead will decline from 15.3 MAF to 14.0 MAF to 13.3 MAF. A lower lake elevation has already derated Hoover Dam from its seasonal normal capability of 2,074 MW, down to 1,767 MW. (This is in addition to a decline of about 500 MW in statewide California hydroelectric capacity for this summer.) Hoover is not expected to go below 1,740 MW in August this year. The effects on energy will be slightly more substantial, with 60 to 90 GWh less output from Hoover each summer month compared to averages, down about 15 percent. Downstream from Hoover, Davis Dam (at Lake Mohave) and Parker Dam (in California at Lake Havasu) will be kept reasonably full, with lake levels and power generation fairly close to seasonal norms.

Conditions of “partial domestic surplus” are still being used to apportion water allocations this year. Imperial Irrigation District is expected to receive about 3.0 MAF, close to 100 percent of average. Most of this water will reach farm fields and the Salton Sea after first passing through a series of run-of-canal hydro plants with 85 MW total nameplate capacity. Metropolitan Water District (MWD) is authorized to divert 0.503 MAF this year, less than half of a full Colorado River Aqueduct, and down from an average 1.2 MAF. Due to the reduced water deliveries from the Colorado River via long-distance conveyance, MWD has relied more heavily on importing water from Northern California using the California Aqueduct, where much more energy is consumed in pumping and lifting than when it is drawn from the Colorado River. MWD also generates some energy at small hydro plants in its distribution network which add up to 139 MW of nameplate capacity. Dry year conditions are expected to increase statewide demand by 300 MW to 600 MW, especially loads for pumping water.

A Note on 2003 Hydro

California rainfall and snowpack patterns in early 2003 were remarkably similar to conditions in early 2004. However, in 2003 there were major storms in mid-April and early May that significantly boosted water supplies from what was 70 percent of average to 84 percent of average. Much of that late-season snowpack began to melt rapidly in late May into early June. As days lengthened and temperatures warmed, rivers swelled and hydro plants ran at full capacity. This abundance of hydro energy in May 2003 often drove down the spot market prices for energy, sometimes all the way to $0/MWh during off-peak hours. This situation will not recur this year. Hydro will not be a factor in driving down natural gas prices this year anywhere in the West.

Last year, our web-published forecast on April 29, 2003 said in-state hydro energy production would be 87 percent of average. This estimate was nicely ruined by the early May 2003 storms. We prepared a final in-house forecast on May 29, 2003, predicting California hydro would be 101 percent of average. This proved to be slightly closer to the mark, but on the optimistic side. From our preliminary Energy Commission data, in-state California hydro production in 2003 was 36,035 GWh in 2003, which is 96.5 percent of the 1983-2001 average (37,345 GWh). The final 2003 figures may change slightly.

Conclusion

Hydro is a high risk, high yield energy resource. Every year begins with large unknowns and uncertainties about water supplies, including volumes, locations, and timing. These uncertainties always create some short-term risks for load-serving utilities. These risks are partially measured and managed by scientific data collection of snowpacks, and collaborative data sharing for hydrologic forecasting. These risks are reduced and mitigated by reservoirs with flexible operations. For utilities, the economic risk associated with below-average energy production from hydro is normally present every winter, and sometimes remains after the rains are gone.